Inter (Part-I) 2021

Chemistry	Group-I	PAPER: I
Time: 2.40 Hours	(SUBJECTIVE TYPE)	Marks: 68

SECTION-I

2. Write short answers to any EIGHT (8) questions: (16)

(i) How is the law of conservation of mass obeyed during stoichiometric calculations?

Ans Stoichiometric calculations are those in which balance chemical equation is used. Balanced chemical equation means that masses of reactant and product are same. This means that law of conservation of mass is obeyed. Otherwise, no calculation is correct.

(ii) Why N_2 and NO have same number of electrons, protons and neutrons? Justify.

Ans **No. of electrons:**

$$N_2 \longrightarrow N + N \longrightarrow 7e^- + 7e^- = 14 \text{ electrons}$$

$$CO \longrightarrow C + O \longrightarrow 6e^- + 8e^- = 14 \text{ electrons}$$

No. of protons:

$$N_2 \longrightarrow N + N \longrightarrow 7p + 7p = 14 \text{ protons}$$

$$CO \longrightarrow C + O \longrightarrow 6p + 8p = 14 \text{ protons}$$

No. of neutrons:

$$N_2 \longrightarrow N + N \longrightarrow 7n + 7n = 14 \text{ neutrons}$$

$$CO \longrightarrow C + O \longrightarrow 6n + 8n = 14 \text{ neutrons}$$

So, N_2 and CO have the same number of electrons, protons and neutrons.

(iii) Define mole. Calculate the gram atoms (moles) in 0.1 g of sodium.

Ans **Mole:** A quantity which contains Avogadro's number of units *i.e.,* atoms, molecules, ions or whatever under consideration is called a mole.

$$\text{No. of gram atoms} = \frac{\text{Mass of element in gram}}{\text{Molar mass}}$$

Mass of sodium = 0.1 g

Molar mass = 23 g/mol

Inter (Part-I) 2021

Chemistry	Group-I	PAPER: I
Time: 2.40 Hours	(SUBJECTIVE TYPE)	Marks: 68

SECTION-I

2. Write short answers to any EIGHT (8) questions: (16)

(i) How is the law of conservation of mass obeyed during stoichiometric calculations?

Ans Stoichiometric calculations are those in which balance chemical equation is used. Balanced chemical equation means that masses of reactant and product are same. This means that law of conservation of mass is obeyed. Otherwise, no calculation is correct.

(ii) Why N_2 and NO have same number of electrons, protons and neutrons? Justify.

Ans **No. of electrons:**

$$N_2 \longrightarrow N + N \longrightarrow 7e^- + 7e^- = 14 \text{ electrons}$$

$$CO \longrightarrow C + O \longrightarrow 6e^- + 8e^- = 14 \text{ electrons}$$

No. of protons:

$$N_2 \longrightarrow N + N \longrightarrow 7p + 7p = 14 \text{ protons}$$

$$CO \longrightarrow C + O \longrightarrow 6p + 8p = 14 \text{ protons}$$

No. of neutrons:

$$N_2 \longrightarrow N + N \longrightarrow 7n + 7n = 14 \text{ neutrons}$$

$$CO \longrightarrow C + O \longrightarrow 6n + 8n = 14 \text{ neutrons}$$

So, N_2 and CO have the same number of electrons, protons and neutrons.

(iii) Define mole. Calculate the gram atoms (moles) in 0.1 g of sodium.

Ans **Mole:** A quantity which contains Avogadro's number of units *i.e.,* atoms, molecules, ions or whatever under consideration is called a mole.

$$\text{No. of gram atoms} = \frac{\text{Mass of element in gram}}{\text{Molar mass}}$$

Mass of sodium = 0.1 g

Molar mass = 23 g/mol

Number of gram atoms of sodium $= \dfrac{0.1\ g}{23\ g\ mol^{-1}}$

$= 0.0043\ mol$

$= \boxed{4.3 \times 10^{-3}\ mol}$

(iv) Draw the beautiful diagram of sublimation process.

Ans

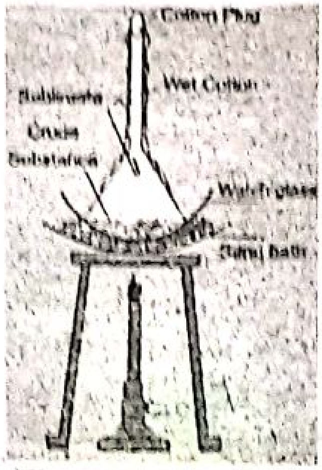

Fig. Sublimation.

(v) Write down the uses of chromatography.

Ans The techniques of chromatography are very useful in organic synthesis for:

(i) Separation, isolation and purification of the products.

(ii) It is very important in qualitative and quantitative analyses.

(iii) It is very important for determination of the purity of a substance.

(vi) What is the physical meaning of R?

Ans When the pressure is in atmospheres, volume in dm^3, then the value of R, used should be $0.0821\ dm^3\ atm\ K^{-1}\ mol^{-1}$.

The physical meaning of this value is that, if we have one mole of an ideal gas at 273.16 K and one atmospheric pressure and its temperature is increased by 1 K, then it will absorb $0.0821\ dm^3$-atm of energy, dm^3-atm is the unit of energy in this situation. Hence, the value of R is a universal parameter for all the gases. It tells us that the Avogadro's number of molecules of all the ideal gases have the same demand of energy.

(vii) Prove Boyle's law in the light of K.M.T.

Ans According to one of the postulates of kinetic theory of gases, the kinetic energy is directly proportional to the absolute temperature of the gas. The kinetic energy of N molecules is $\frac{1}{2} mN\overline{c^2}$.

So $\frac{1}{2}mN\bar{c}^2 \propto T$

$$\frac{1}{2}mN\bar{c}^2 = kT \quad \ldots (i)$$

where k is the proportionality constant. According to the kinetic equation of gases,

$$PV = \frac{1}{3}mN\bar{c}^2$$

Multiplying and dividing by 2 on right hand side,

$$PV = \frac{2}{3}\left(\frac{1}{2}mN\bar{c}^2\right) \quad \ldots (ii)$$

Putting equation (i) into equation (ii),

$$PV = \frac{2}{3}kT \quad \ldots (iii)$$

If the temperature (T) is constant, then right hand side of equation (iii) *i.e.*, $\frac{2}{3}kT$ is constant. Let that constant be k'.

So, $PV = k'$ (which is Boyle's law)

Hence at constant temperature and at fixed number of moles, the product PV is a constant quantity.

(viii) What are the two characteristics of plasma?

Ans Following are the two characteristics of plasma state:

1. A plasma must have sufficient number of charged particles. So, as a whole, it exhibits a collective response to electric and magnetic field.
2. Although, plasma includes electrons and ions and conducts electricity, it is macroscopically neutral. In measurable quantities, the number of electrons and ions are equal.

(ix) Write down the quantitative statement of Charles's law.

Ans It is a quantitative relationship between temperature and volume of a gas and was given by French scientist J. Charles in 1787. According to this law, the volume of the given mass of a gas is directly proportional to the absolute temperature when the pressure is kept constant.

$V \propto T$ (when pressure and number of moles are constant)

$V = kT$

$$\frac{V}{T} = k$$

(x) Define heat of solution.

Ans The standard enthalpy of a solution is the amount of heat absorbed or evolved when one mole of a substance is dissolved in so much solvent that further dilution results in no detectable heat change.

For example, enthalpy of solution ($\Delta H^{\circ}_{sol.}$) of ammonium chloride is +16.2 kJ mol^{-1}.

(xi) How will you justify that the lowering of vapour pressure is a colligative property?

Ans Relative lowering of vapour pressure is equal to the mole fraction of solute.

$$X_2 = \frac{\Delta p}{p_o}$$

The solute is non-volatile and non-electrolyte. Thus, conditions for colligative properties are fulfilled. Relative lowering of vapour pressure is hence, a colligative property, as it depends upon no. of solute and solvent molecules.

(xii) Differentiate between ideal and non-ideal solutions.

Ans **Ideal and Non-Ideal Solutions:**

When two or more than two liquid substances are mixed, the solutions may be ideal or non-ideal. To distinguish between such solutions, we look at the following aspects:

(i) If the forces of interactions between the molecules of different components are same as when they were in the pure state, they are ideal solutions, otherwise non-ideal.

(ii) If the volume of solution is not equal to the sum of the individual volumes of the components, the solution is non-ideal.

(iii) Ideal solutions have zero enthalpy change as their heat of solution.

(iv) If the solutions obey Raoult's law, then they are ideal. This is one of the best criterion for checking the ideality of a solution.

3. Write short answers to any EIGHT (8) questions: 16

(i) Ethyl alcohol is soluble in water. Why?

Ans Water is the best example of H-bonded system. Similarly,

ethyl alcohol (C_2H_5OH) also has the tendency to form bonds. So, ethyl alcohol can dissolve in water because both can form hydrogen bonds with each other.

(ii) Explain H-bonding in deoxyribonucleic acid (DNA).

Ans Deoxyribonucleic acid (DNA) has two spiral chains. These are coiled about each other on a common axis. In this way, they give a double helix. This is 18-20 A in diameter. They are linked together by H-bonding between their sub-units.

(iii) What do you know about anisotropy? Explain with example.

Ans Some of the crystals show variation in physical properties depending upon the direction. Such properties are called anisotropic properties and the phenomenon is referred to as anisotropy.

For example, electrical conductivity of graphite is greater in one direction than in another. Actually, electrons in graphite are mobile for electrical conduction parallel to the layers only. Therefore, its conductivity in this direction is far better than perpendicular to the other direction. Similarly, cleavage itself is an anisotropic behaviour.

(iv) What is allotropy? Give one example.

Ans The existence of an element in more than one crystalline forms is known as allotropy and these forms of the element are called allotropes or allotropic forms. Sulphur, phosphorus, carbon and tin are some important examples of elements which show allotropy.

(v) Write two nuclear reactions for production of gamma (γ) radiations and β-particle.

Ans When slow moving neutrons hit the Cu metal, gamma γ radiations are emitted. The radioactive ${}^{66}_{29}Cu$ is converted into ${}^{66}_{30}Zn$.

$$ {}^{65}_{29}Cu + {}^{1}_{0}n \longrightarrow {}^{66}_{29}Cu + h\nu \quad (\gamma\text{-radiations}) $$

$$ {}^{66}_{29}Cu \longrightarrow {}^{66}_{30}Zn + {}^{0}_{-1}e $$

Actually, neutron is captured by the nucleus of ${}^{65}_{29}Cu$ and ${}^{66}_{29}Cu$ is produced. This radioactive ${}^{66}_{29}Cu$ emits an electron (β-particle) and its atomic number increases by one unit.

(vi) Write defect of Rutherford Atomic Model.

Ans Following are the defects in Rutherford's atomic model:

1. The outer electrons could not be stationary.
2. The behaviour of electrons remained unexplained in the atom.
3. Planet-like picture was defective because the moving electron must be accelerated towards the nucleus.

(vii) Define Heisenberg's uncertainty principle and write its mathematical equation.

Ans Certainty in the determination of one quantity introduces uncertainty in the determination of the other quantity.

Suppose that Δx is the uncertainty in the measurement of the position and ΔP is the uncertainty in the measurement of momentum of an electron, then

$$\Delta x\ \Delta p \geq \frac{h}{4\pi}$$

This relationship is called uncertainty principle.

(viii) Write name of different quantum numbers.

Ans There are four quantum numbers which can describe the electron completely:

(1) Principal quantum number (n)
(2) Azimuthal quantum number (ℓ)
(3) Magnetic quantum number (m)
(4) Spin quantum number (s)

(ix) Write Henderson's equation for acidic and basic buffer.

Ans Henderson's equation for acidic buffer:

$$pH = pK_a + \log\frac{[salt]}{[acid]}$$

Hnderson's equation for basic buffer:

$$pOH = pK_b + \log\frac{[salt]}{[base]}$$

(x) Why do we need buffer solution?

Ans It is a common experience that the pH of the human blood is maintained at pH 7.35, if it goes to 7.00 or 8.00, a person may die.

Sometimes one wants to study a reaction under conditions that would suffer any associated change in the pH of

the reaction mixture. So, by suitable choice of the solutes, a chemist can ensure that a solution will not experience more than a very small change in pH, even if a small amount of a strong acid or a strong base is added. Buffers are important in many areas of chemistry and allied sciences like molecular biology, microbiology, cell biology, soil sciences, nutrition and the clinical analysis.

(xi) Explain specific rate constant briefly.

Ans By applying the law of mass action to a general reaction.

$$aA + bB \longrightarrow cC + dD$$

$$\text{Rate of reaction} = k\,[A]^a\,[B]^b$$

This expression is called rate equation. The brackets [ ] represent the concentrations and the proportionality constant k is called rate constant or velocity constant for the reaction.

If $[A] = 1 \text{ mol dm}^{-3}$ and $[B] = 1 \text{ mol dm}^{-3}$

$$\text{Rate of reaction} = k \times 1^a \times 1^b = k$$

Hence the specific rate constant of a chemical reaction is the rate of reaction when the concentrations of the reactants are unity. Under the given conditions, k remains constant, but it changes with temperature.

(xii) What is zero order reaction? Give one example.

Ans A reaction is said to be zero order if it is entirely independent of the concentration of reactant molecules. Photochemical reactions are usually zero order.

4. Write short answers to any SIX (6) questions: (12)

(i) Define bond order. Give one example.

Ans **Bond Order:** The number of bonds formed between two atoms after the atomic orbitals overlap, is called the bond order and is taken as half of the difference between the number of bonding electrons and anti-bonding electrons. The number of bonds formed between H-atoms in hydrogen molecule may be calculated as follows:

Number of electrons in the bonding orbitals = 2

Number of electrons in the anti-bonding orbitals = 0

$$\text{Bonding order} = \frac{2-0}{2} = 1$$

(ii) Draw diagram for formation of bonding and anti-bonding molecular orbitals for H_2 molecule.

Ans

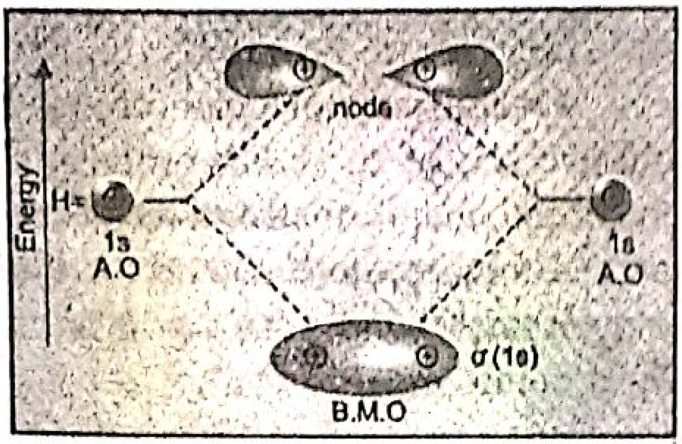

Fig. Formation of bonding and anti-bonding molecular orbitals for hydrogen molecule (H_2).

(iii) Define sigma bond and pi-bond.

Ans A single bond is formed when two partially filled atomic orbitals overlap in such a way that the probability of finding the electron is maximum around the line joining the two nuclei.

A π-bond is formed by the sideways overlap of two half-filled co-planar p-orbitals in such a way that the probability of finding the electron is maximum perpendicular to the line joining the two nuclei.

(iv) Define atomic orbital hybridization.

Ans In order to explain the formation of bonds and shapes or geometry of molecules, the idea of hybridization has been introduced.

According to this, atomic orbitals differing slightly in energy intermix to form new orbitals, which are called hybrid atomic orbitals. They differ from the parent atomic orbitals in shape and possess specific geometry. The atomic orbital hybridization gives a satisfactory explanation for the valency of elements. In some cases, electrons belonging to ground state are promoted to excited state as a result of which there is an increase in number of unpaired electrons.

(v) What is first law of thermodynamics? Give its mathematical equation.

Ans The first law of thermodynamics, also called the law of conservation of energy, states that energy can neither be created nor destroyed, but can be changed from one form to

another. In other words, a system cannot destroy or create energy. However, it can exchange energy with its surroundings in the form of heat and work.

Mathematical equation of this law can be written as:

$$\Delta E = q_v$$

This shows that a change in internal energy of a system, at constant volume is equal to heat absorbed by the system (q_v).

(vi) Define enthalpy of combustion ΔH^o_c.

Ans The standard enthalpy of combustion of the substance is the amount of heat evolved when one mole of the substance is completely burnt in excess of oxygen under standard conditions. It is denoted by ΔH^o_c.

For example, standard enthalpy of combustion of ethanol ΔH^o_c is -1368 kJ mol^{-1}.

(vii) How anodized aluminium is prepared in an electrolytic cell?

Ans Anodized aluminium is prepared by making it an anode in an electrolytic cell containing dilute sulphuric acid or chromic acid, which coats a thin layer of oxide on it. The aluminium oxide layer resists attack of corrosive agents. The freshly anodized aluminium is hydrated and can absorb dyes.

(viii) Draw a diagram of standard hydrogen electrode (SHE).

Ans

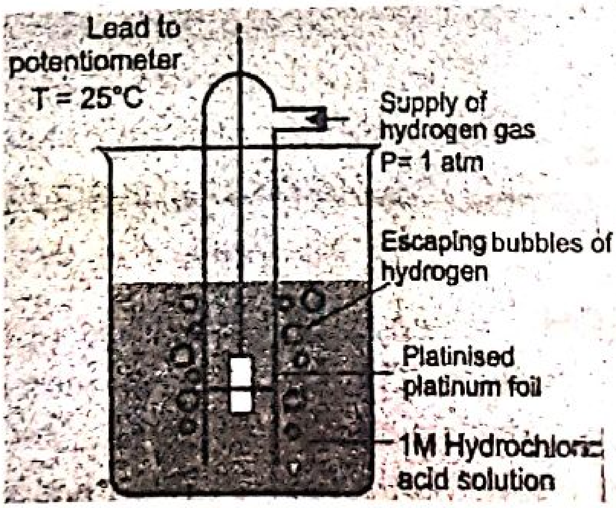

Fig. Standard hydrogen electrode (SHE).

(ix) Define electrochemical series.

Ans When elements are arranged in the order of their standard electrode potentials on the hydrogen scale, the resulting list is known as electrochemical series.

SECTION-II

NOTE: Attempt any Three (3) questions.

Q.5.(a) NH_3 gas can be produced by heating together NH_4Cl and $Ca(OH)_2$. If a mixture containing 100 g of each solid is heated, then calculate the number of grams of NH_3 produced. **(4)**

$$2NH_4Cl + Ca(OH)_2 \longrightarrow CaCl_2 + 2NH_3 + 2H_2O$$

Ans Convert the given amounts of both reactants into their number of moles.

Mass of NH_4Cl = 100 g

Molar mass of $NH_4Cl = 53.5\ g\ mol^{-1}$

$$\text{Moles of } NH_4Cl = \frac{100\ g}{53.5\ g\ mol^{-1}} = 1.87$$

Mass of $Ca(OH)_2$ = 100 g

Molar mass of $Ca(OH)_2 = 74\ g\ mol^{-1}$

$$\text{Moles of } Ca(OH)_2 = \frac{100\ g}{74\ g\ mol^{-1}} = 1.35$$

Compare the number of moles of NH_4Cl with those of NH_3

NH_4Cl	:	NH_3
2	:	2
1	:	1
1.87	:	1.87

Similarly, compare the number of moles of $Ca(OH)_2$ with those of NH_3.

$Ca(OH)_2$	:	NH_3
1	:	2
1.35	:	2.70

Since, the number of moles of NH_3 produced by 100 g or 1.87 moles of NH_4Cl are less, so NH_4Cl is the limiting reactant. The other reactant, $Ca(OH)_2$ is present in excess.

Hence Mass of NH_3 produced = 1.87 moles × 17 g mol^{-1}

= 31.79 g

(b) Explain isomorphism with examples. (4)

Ans Isomorphism is the phenomenon in which two different substances exist in the same crystalline form. These different substances are called isomorphs of each other. A crystalline form is independent of the chemical nature of the atoms and depends only on the number of atoms and their way of combinations.

Mostly the ratio of atoms in various compounds is such that isomorphism is possible. Their physical and chemical properties are quite different from each other. Anyway, isomorphic substances crystalline together in all proportions in homogeneous mixtures.

Following examples tell us the nature of the compound, their crystalline forms and the ratio of their atoms:

Isomorphs	Crystalline Form	Atomic Ratio
$NaNO_3$, KNO_3	rhombohedral	1:1:3
K_2SO_4, K_2CrO_4	orthorhombic	2:1:4
$ZnSO_4$, $NiSO_4$	-do-	1:1:4
NaF, MgO	cubic	1:1
Cu, Ag	cubic	1:1
Zn, Cd	hexagonal	1:1

The structures of the negatively charged ions like NO_3^{1-} and CO_3^{2-}, are the same. Similarly, shapes of SO_4^{2-} and CrO_4^{2-} are also alike. CO_3^{2-} and NO_3^{1-} are triangular planar units, while SO_4^{2-} and CrO_4^{2-} are both tetrahedral.

Q.6.(a) Give postulates of kinetic molecular theory. (4)

Ans For Answer see Paper 2016 (Group-II), Q.6.(a).

(b) Derive an expression to determine radius of an orbit using Bohr's model. (4)

Ans For Answer see Paper 2017 (Group-I), Q.6.(b).

Q.7.(a) What is sp^2 hybridization? How it explains structure of ethene? (4)

Ans **sp^2-Hybridization:**

In sp^2 hybridization, one 's' and two 'p' atomic orbitals of an atom intermix three orbitals called sp^2 hybrid orbitals.

Ethene ($CH_2 = CH_2$)

Electronic configuration of $_6C$ is

$$_6C = (\text{ground state}) = \underset{1s}{\boxed{\uparrow\downarrow}}\ \underset{2s}{\boxed{\uparrow\downarrow}}\ \underset{2p_x}{\boxed{\uparrow}}\ \underset{2p_y}{\boxed{\uparrow}}\ \underset{2p_z}{\phantom{\boxed{\uparrow}}}$$

$$_6C = (\text{excited state}) = \underset{1s}{\boxed{\uparrow\downarrow}}\ \underset{2s}{\boxed{\uparrow}}\ \underset{2p_x}{\boxed{\uparrow}}\ \underset{2p_y}{\boxed{\uparrow}}\ \underset{2p_z}{\boxed{\uparrow}}$$

$$_6C = (\text{hybridized state}) = \underset{1s}{\boxed{\uparrow\downarrow}}\ \underset{sp^2}{\boxed{\uparrow}}\underset{sp^2}{\boxed{\uparrow}}\underset{sp^2}{\boxed{\uparrow}}\ \underset{2p_z}{\boxed{\uparrow}}$$

In the formation of ethene molecule, each carbon atom undergoes sp^2 hybridization to form three hybrid orbitals which are coplanar and are oriented at an angle of 120°. Each atom is left with one half-filled p-orbital perpendicular to the planar sp^2 hybrid orbitals. One of the p-orbitals does not take part in hybridization. Each carbon atom undergoes sp^2-s overlaps with two hydrogen atoms and sp^2-sp^2 overlap between themselves to form sigma bonds. These overlaps lead to the shapes shown in Fig. The partially filled p-orbitals undergo sideways overlap to form a p-bond.

So, a π-bond is formed by the sideways overlap of two half-filled co-planar p-orbitals in such a way that the probability of finding the electron is maximum perpendicular to the line joining the two nuclei. It should be made clear that π-bond is formed between two atoms only when they are already bonded with a sigma bond.

The two clouds of the π-bond are perpendicular to the plane in which five π-bonds are lying. Just like σ-bond, π-bond can be represented by a line.

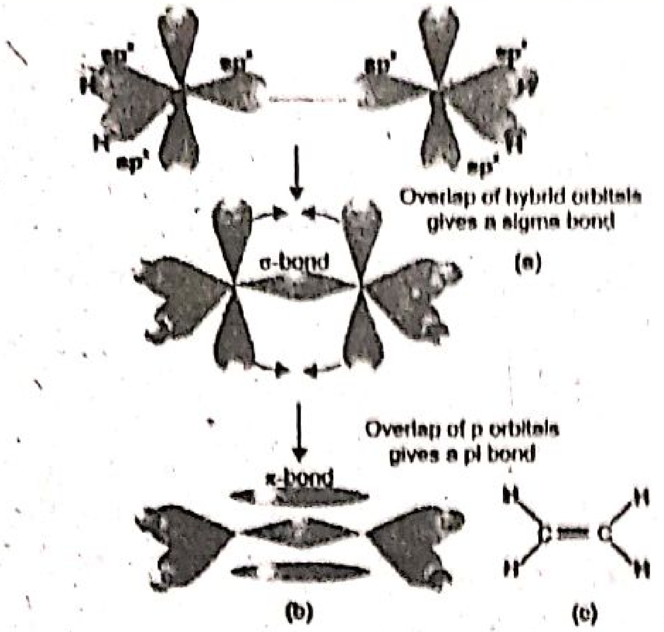

Fig. Formation of one sigma between two carbon atoms and one p-bond in C_2H_4.

(b) What is Hess's law? Explain by giving two examples. (4)

Ans For Answer see Paper 2019 (Group-I), Q.7.(b).

Q.8.(a) Calculate the pH of a buffer solution in which 0.11 molar CH_3COONa and 0.09 molar acetic acid solutions are present. K_a for the CH_3COOH is 1.85×10^5. (4)

Ans 0.11 M CH_3COONa solution means that 0.11 moles are dissolved in 1 dm^3 of solution.

$$[CH_3COONa] = 0.11\ M$$

$$[CH_3COOH] = 0.09\ M$$

$$K_a \text{ of } CH_3COOH = 1.85 \times 10^{-5}$$

$$pK_a = -\log(1.8 \times 10^{-5}) = 4.74$$

$$pH = pK_a + \log\frac{[salt]}{[base]}$$

$$pH = 4.74 + \log\frac{0.11}{0.09}$$

$$pH = 4.74 + 0.087 = \boxed{4.83}$$

Since, the concentration of CH_3COONa is more than that of CH_3COOH, so pH of buffer is greater than 4.74. In other

words, the solution has developed the properties of a base, because CH_3COONa has Na^+ ion which is from a strong base.

(b) Define half-life period. How order of reaction can be determined by knowing half-life of a reaction? (4)

Ans Half-life of a reaction is inversely proportional to the initial concentration of reactants raised to the power one less than the order of reaction.

Therefore, $(t_{1/2})_n \propto \frac{1}{a^{n-1}}$

Let us perform a reaction twice by taking two different initial concentrations 'a_1' and 'a_2' and their half-life periods are found to be t_1 and t_2, respectively.

$$t_1 \propto \frac{1}{a_1^{n-1}} \quad \text{and} \quad t_2 \propto \frac{1}{a_2^{n-1}}$$

Dividing the two relations: $\frac{t_1}{t_2} = \left[\frac{a_2}{a_1}\right]^{n-1}$

Taking log on both sides: $\log\frac{t_1}{t_2} = (n-1)\log\left[\frac{a_2}{a_1}\right]$

Rearranging $n = 1 + \dfrac{\log\left[\frac{t_1}{t_2}\right]}{\log\left[\frac{a_2}{a_1}\right]}$

So, if we know the two initial concentrations and two half-life values, we can calculate the order of reaction (n).

Q.9.(a) What are colligative properties of solutions? Explain elevation of boling points. (4)

Ans **Colligative Properties of Solutions**

The colligative properties are the properties of solution that depend on the number of solute and solvent molecules or ions. Following are colligative properties of dilute solution:

(i) Lowering of vapour pressure
(ii) Elevation of boiling point
(iii) Depression of freezing point
(iv) Osmotic pressure

Elevation of Boiling Point

The presence of a non-volatile non-electrolyte solute in the solution decreases the vapour pressure of the solvent. Greater the concentration of solute, greater will be the lowering of vapour pressure. Therefore, the temperature at which a solvent in the solution state boils is increased.

In order to understand it, determine the vapour pressures of a solvent at various temperatures. Plot a graph between temperatures on x-axis and vapour pressures on y-axis. A rising curve is obtained with the increase of temperature. The slope of the curve at high temperature is greater, which shows that at high temperature the vapour pressure increases more rapidly. Temperature T_1 on the curve AB which is for the pure solvent, corresponds to the boiling point of the solvent. The solvent boils when its vapour pressure becomes equal to the external pressure represented by p^o.

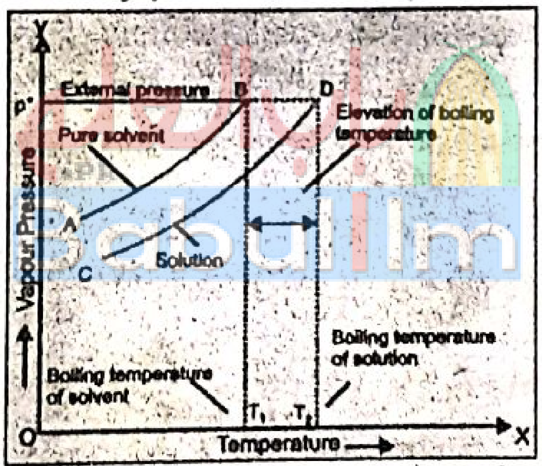

Fig. Elevation of boiling temperature curve.

When the solute is added in the solvent and vapour pressures are plotted vs temperatures, then a curve CD is obtained. This curve is lower than the curve AB because vapour pressures of solution are less than those of pure solvent. Solution will boil at higher temperature T_2 to equalize its pressure to p^o. The difference of two boiling points gives the elevation of the boiling point ΔT_b.

The higher the concentration of solute, the greater will be the lowering in vapour pressure of solution and hence higher will be its boiling point. So, elevation of boiling point ΔT_b is direclty proportional to the molality of solution.

$$T_b \propto m \quad \text{... (i)}$$

$$\Delta T_b = K_b m \quad \text{... (ii)}$$

where K_b is called the ebullioscopic constant or molal boiling point constant.

According to equation (ii), molality of any solute determines the elevation of boiling point of a solvent. You may dissolve 6 g of urea in 500 g of H_2O or 18 g of glucose in 500 g of H_2O both give 0.2 molal solution and both have same elevation of boiling points, *i.e.*, 0.1°C, which is 1/5th of 0.52°C. We say that ΔT_b (not T) is a colligative property.

We know that

$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Molar mass of solute}} \times \frac{1}{\text{Mass of solvent in kg}}$$

$$\text{or} \quad (m) = \frac{W_2}{M_2}\,\frac{1}{W_1/1000} = \frac{1000\,W_2}{M_2\,W_1} \quad \text{... (iii)}$$

Putting the value of m from equation (iii) into equation (ii),

$$\Delta T_b = K_b\,\frac{1000\,W_2}{M_2\,W_1} \quad \text{... (iv)}$$

Rearranging equation (iv),

$$\text{Molecular mass } (M_2) = \frac{K_b}{\Delta T_b} \times \frac{W_2}{W_1} \times 1000 \quad \text{... (v)}$$

Equation (v) can be used to determine the molar mass of a non-volatile and non-electrolyte solute in a volatile solvent.

(b) Describe the construction and working of standard hydrogen electrode. (4)

Ans **Standard Hydrogen Electrode (SHE)**

A standard hydrogen electrode which is used as a standard is shown in Fig. It consists of a piece of platinum foil, which is coated electrolytically with finely divided platinum black

to give it a large surface area and suspended in one molar solution of HCl. Pure hydrogen gas at one atmosphere pressure is continuously bubbled into 1 M HCl solution. The platinum acts as an electrical conductor and also facilitates the attainment of equilibrium between the gas and its ions in solution. The potential of this electrode is arbitrariliy taken as zero.

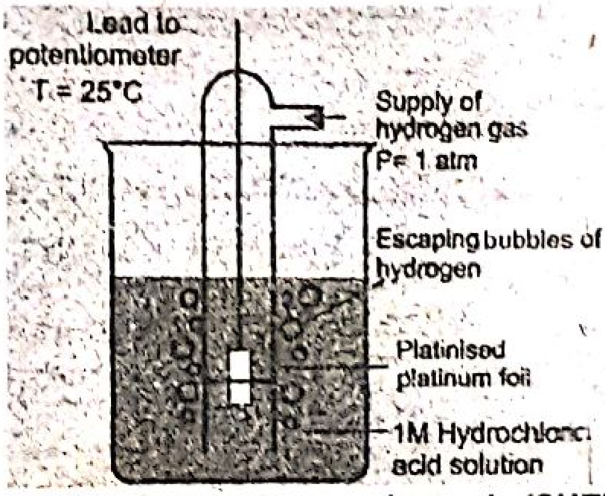

Fig. Standard hydrogen electrode (SHE).